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HIGHER EDUCATION AND THE NEW TECHNOLOGIES  
Sixth International Conference on Higher Education

University of Lancaster

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Lancaster, England

University of California

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One of the most persistent dreams of the twentieth century has been the hope that education and the search for new knowledge will bring about lasting improvements in the human condition. That aspiration was eloquently expressed by the American scientist J. Robert Oppenheimer in 1953:

The open society, the unrestricted access to knowledge, the unplanned and uninhibited association of men for its furtherance--these are what may make a vast, complex, ever growing, ever changing, ever more specialized world, nevertheless a world of human community.

And one of the most promising means of bringing about that "unrestricted access to knowledge" has been the new technologies that in recent decades have made access to information easier, faster, and more complete than ever before.

Computers, satellites, cable, videotape--these and similar developments have opened up educational possibilities with profound and far-reaching implications. Indeed Eric Ashby has hailed the advent of the new instructional technologies as the "Fourth Revolution" in learning, destined to join such advances as the creation of the school, the adoption of the written word as the medium of learning, and the invention of printing as one of the very few fundamental changes in the long course of human learning.

The possibilities of this revolution are breathtaking. We now have the capacity to bring education to previously undreamed of numbers of students. We are no longer tied to a specific place or a specific time for teaching and learning. We can give instructors more scope to concentrate on substantive tasks by using machines for routine teaching activities. We can perform research that was hitherto impossible because of these new techniques. Although the impact of the technological revolution has been unevenly felt, and its riches--so far, at least--unevenly distributed, we can be sure that sooner or later its reverberations will echo in the ways teaching, research, and administration are carried out at colleges and universities everywhere. Some of its results are already clear; others can be guessed at; still others--especially its long term effects--probably cannot even be imagined.

I would like to discuss these new technologies from two perspectives. The first is what they are enabling us to do in teaching and research, drawing on the experience of my own institution, the University of California. The second is their implications for the future, some of the issues and possibilities they raise for us as educators in a world that is becoming ever more technological.

Of all the transformations the new technology will bring, probably the most pervasive and the most profound will be those associated with the computer. That is because the discovery, creation, and transmission of knowledge are fundamental purposes of the university. And the computer revolution is putting into our hands unprecedented capacity to process, store, analyze, and retrieve information of all kinds.

This revolution is already evident. You may have read recently that 25% of the entering students at the Massachusetts Institute of Technology arrive possessing their own microcomputers. Even liberal arts colleges, which would seem to have fewer reasons to involve themselves with computer technology, are showing a lively interest in its possibilities. One reason, of course, is simply the recognition that it is becoming increasingly difficult to understand our society and our world without some grasp of the nature and uses of information processors. Another is the

applications of computer technology to teaching and learning in all disciplines, from the storing of entire art history libraries on a few video discs to the use of interactive computers as teachers of composition.

As organizers of information, computers have proven their utility in scholarship and research as well as in teaching. At our Santa Barbara campus, for example, information from the Domesday Book is being fed into a computer so that, for the first time, scholars can analyze quickly and comparatively its more than three million pieces of information about land holdings in the England of William the Conqueror. And computers are being used to publish the first complete and accurate collection of the works of Henry David Thoreau, many of whose writings were altered by well-meaning friends and relatives after his death. Editors enter the original and unaltered text onto computer diskettes, which are encoded with typesetting directions so that the manuscript can be typeset directly from the diskette. This arrangement gives editors unparalleled control over the publication process and virtually eliminates the possibility that inadvertent changes in spelling, punctuation, word usage, and the like will find their way into the published work.

In scientific research, the impact of the computer has been little less than spectacular. For example, computer modeling of molecules is a valuable new technique that chemical

researchers at the University of California and elsewhere are using to search for new pharmaceuticals. Computers are also giving us a window on the human body through techniques like CT scanning--a new terminology for what used to be called CAT scanning--which draw on the ability of computers to construct, using millions of pieces of information, a picture of the interior of the human anatomy. CT scanning has been used successfully in radiology to locate precisely organs and tissues so that radiation treatment can be directed with pinpoint accuracy. Such breakthroughs are immensely promising for patient care and for advances in the treatment of disease.

Computers have given us a window not only on the human body but also on the universe beyond our world. Advances in computer science, for example, have raised the possibility of greatly expanding the range of current optical telescopes. For almost four hundred years reflector-type optical telescopes have relied on the use of a single reflecting mirror that gathers in light and then reflects the image back to a focal point. Larger and more powerful mirrors have been constructed over time, but their size has been limited by the technical problems created by their enormous weight and by the financial costs associated with building gigantic single mirrors.

A few years ago, however, University of California astronomers realized that the technical problems could be solved by replacing the single massive mirror with a system of smaller ones. These smaller mirrors function as a single reflecting surface if automatically aligned with one another by a computer. The computer constantly corrects for disturbances in the orientation of the segments to each other, changes in temperature, shifting winds, and changes in the position of the telescope--at a rate faster than the human eye can see.

The Ten Meter Telescope, as it is called, eliminates the weight problem because its design requires that it weigh only 158 tons--relatively light for a giant telescope. The new design also makes possible a primary mirror that has twice the diameter of the largest telescope in use today. As a result, the TMT will enable astronomers to study nine times more volume of the universe than has been possible to date. It will also be able to "see" or resolve the images of objects over ten billion light years away. When it is built for the University of California on Mauna Kea in Hawaii, it will be the largest optical telescope in the world.

TMT would have been impossible even ten years ago because we lacked the computer technology that permits the delicate and ceaseless readjustments fundamental to the telescope's design. But advances in computer science have now given us

a powerful new tool for investigating fundamental questions about our universe and how it began.

The transforming influence of the new technologies has been felt even within that most traditional of institutions, the library. The phenomenal growth of knowledge in this century has taxed the abilities of libraries to maintain adequate and up to date collections. At the same time, the phenomenal growth of higher education has meant that more and more students and scholars are seeking access to the library and its resources.

At the University of California, an academic community that includes nine campuses, 145,000 students, and 100,000 faculty and staff, the size and quality of our libraries are obviously issues of crucial importance. We have over 100 libraries on our campuses, consisting of collections that range from the very small to the very large, from the very general to the very specialized, many of them unique in the world, totalling in all some 18 million volumes. Within the United States, only the Library of Congress has more extensive holdings.

Access to this splendid but geographically scattered collection has been an important policy issue at the University for many years. The question of access has recently taken on new urgency for two reasons. First, the



economic problems of the last decade have prompted the effort to avoid duplication in campus holdings and to encourage intercampus sharing of library resources. Second, despite the size and diversity of the University's collections as a whole, individual campus library holdings had gaps and inadequacies that could be solved by improving access to other campuses's collections. Thus, both internal and external considerations pointed to the desirability of a policy for access that would begin from the premise that the University's holdings should be thought of as a single library, rather than as one hundred separate ones.

If we were to ask students and faculty throughout the system to think in terms of one library, however, we first had to solve a fundamental problem: how were they to know what this vast and geographically separate collection contained?

It was clear from the outset that card catalogs were not the answer. In fact the utility of card catalogs even for individual campus collections was coming into question. Berkeley's catalogs, the oldest and largest, contained 8 million cards, which meant that the logistics of keeping it up to date were cumbersome and complex. Duplication of the Universitywide catalog for each of the campuses was another problem. Book catalogs could be reproduced for each campus but had significant disadvantages as well, among them the

fact that they would be out of date as soon as they were published.

After long and extensive consultation, and after examining various forms of automation, we decided to close our card catalogs and use computerized records instead. And thus MELVYL was born.

MELVYL (the name comes from Melvil Dewey, the inventor of the Dewey decimal cataloging system) is an online union catalog that builds on the computer's ability both to store huge amounts of information and to provide access to that information conveniently and at a distance. It consists first of all of a database--at present, more than a million and a half book and serial titles have been entered--which is stored at the University's administrative headquarters in Berkeley. Terminals at each of the nine campuses, linked by an extensive telecommunications network, will provide instant and easy access to that database. Each terminal consists of a screen and a keyboard, which patrons use to ask for the author, title, or subject in which they are interested. Terminals are easy to use; if thwarted, one simply types "HELP" and instructions on what to do next appear on the screen. At present we have about 200 terminals located throughout the University; eventually we will have more than 600. Moreover, persons using their own

terminals or personal computers will be able to gain access by dialing in.

MELVYL solves the problem of the unwieldy card catalogs by taking the catalogs to the user--rather than the reverse--and eventually we will have terminals not only in libraries but in dormitories, offices, and other public locations as well. It solves the problem of keeping the catalog current because computer technology allows for quick and easy revision of records. Moreover, as a computer-based system it can retrieve information in ways that were impossible using the old card catalogs. And the terminals used for the catalog can be used to provide access to other stored information. Conversely, terminals that are now being used for other purposes can be used to gain access to the union catalog.

But one of the most exciting aspects of MELVYL is the possibilities it opens up for increasing access to a great library collection and for sharing resources. Satellite technology will eventually make it possible for the wealth of MELVYL's holdings to be shared with other universities throughout the country; there is no reason why they cannot ultimately be shared internationally as well.

Just as MELVYL is expanding the geographical reach of the library, so it is opening up new possibilities for the

services the library can offer. At present, MELVYL is a flexible and efficient catalog. Later, we will be able to add secondary bibliographical services--for example, by making available not just the titles of serials but the articles, abstracts, and other contents of those serials. Numerical data of all kinds--demographic, economic, financial--can be added for easy access by MELVYL users. Eventually we may be able to add images--architectural drawings, medical illustrations, pictures; the Library of Congress is already experimenting in this area.

MELVYL is forcing us to rethink what a library is and what it can do. And from that perspective MELVYL is exciting not just because of what it is but because of what it portends. For the first time in the history of scholarship, the scholar need not come to the library; it can come to the scholar in more timely and less encumbering ways. And it can be made to go anywhere in the world, theoretically at least, linking the world's great collections into one vast treasure house of learning.

I have used MELVYL as an example of computer technology because computers are so central to its function and design. But just as important to the success of MELVYL is the telecommunications network that will link the system into one.

Until the last few years, the telecommunications needs of our campuses were handled on a problem by problem basis, as specific administrative or academic or instructional needs arose. Each campus decided for itself the extent to which television and related technologies were to be used for teaching, research, and public service. Video tapes, for example, have been used to record lectures by distinguished visitors; to illustrate the research process and its results; to bring the great dance and drama of the world to students--and their own performances as well, taped for analysis and review.

Although some of our campuses have used microwave or satellite technology for teaching or other purposes, it is only in recent years that we have thought seriously about a coordinated approach to the use of telecommunications throughout the University. And that is due in large part to a practical and external reason: we have known for some time that the divestiture of the largest telecommunications company in the United States--the American Telephone and Telegraph Company--and the general deregulation of the telecommunications industry would mean rapidly spiralling costs for large users like the University of California. As a result, we have been considering the possibility of establishing our own network for handling voice, data, and--at some future time--video communication among our campuses.

We don't yet know whether this system, if it turns out to be economically and technically feasible, will be based on microwave, satellite, fiber optics, or some combination of these technologies. We do know that it will have to be compatible with technology already being used on our campuses. And we are also thinking in terms of how this system, besides containing costs, can be used to improve teaching, research, and public service at the University of California.

The Berkeley campus, for example, already broadcasts upper division and graduate engineering courses to neighboring Stanford University and to several private high technology corporations as well. Berkeley has just installed an antenna dish that will enable it to receive--at a reasonable cost--live television transmissions from a network of universities throughout the country. It has also used television to mount a part-time professional degree program in business administration in San Francisco. At our Irvine campus, cable television is used as part of a Teacher Education Program conducted jointly with a local school district. Medical schools on our San Francisco and San Diego campuses use microwave to televise grand rounds and beam them to other hospitals in the area. In San Diego, this practice has been so successful as a means of continuing education for physicians that grand rounds are

now televised to hospitals throughout the county, and plans are in the works to broadcast at the national level as well.

A telecommunications net linking all of our campuses raises some intriguing possibilities, both for expanding these kinds of activities and adding others. It has been suggested, for example, that teleconferencing could eliminate some of the inevitable intercampus travel that goes on because of the need for academic and administrative meetings. We also have a number of research units that involve more than one campus, and faculty in these research centers might be able to make good use of teleconferencing for collaborative research and other cooperative activities, both within and beyond the University. Guest performers and artists could present demonstrations and workshops that could be beamed to a number of campuses. Special events could be televised within the University and to audiences outside the University as well. And of course the opportunities for collaboration and sharing are just as applicable to universities around the country--perhaps around the world--as they are to the nine campuses that make up the University of California.

#### Implications for the Future

It is clear that the new technologies are doing far more than giving us an added margin of flexibility in teaching

and research. Taken together, they represent one of the greatest opportunities for change in the history of higher education. Along with the explosion of knowledge in this century has come the computer, a powerful tool for organizing and dealing with the masses of information this explosion has created. And along with it have also come advances in communications that mean we can share the riches of learning with increasing numbers of people, including those who for one reason or another do not fit the traditional student pattern.

For the new technologies are breaking down the old barriers of distance, geography, race, nationality, language, and religion. They are forcing us to revise many long held assumptions, among them how we think about the university itself.

We have tended to think of universities as more or less isolated enclaves, self-contained and geographically bound. In many respects they are and will continue to be. But the boundaries of the university are expanding along with our growing ability to break free of the traditional constraints of distance and time. In the intellectual realm, the new technologies are giving us the means to investigate the unimaginably large--the Ten Meter Telescope--and the incredibly small--the electron microscope. In the academic community itself, they are transforming familiar practices



into new possibilities. We have long had visiting professors and arrangements for interlibrary loan; now the electronic age is making it possible for both the lecture hall and the library to reach new audiences and new patrons in different ways. We have always assumed that students and scholars must come to the university, but now some of the university can come to them. We have always considered collaboration in teaching and research among widely separated institutions difficult and only occasionally possible, but now boundaries and distances are being erased. If nine campuses in a single university can be linked together in a telecommunications network that runs the length of California, then colleges and universities in Chicago and Boston and Montreal can be linked too. And so can universities in Lancaster, Paris, Padua, Copenhagen, and Uppsala. The technology is already here.

What this means is that the new technologies are pushing us not only towards a more global learning environment but also towards the internationalization of learning. And higher education faces an enormous challenge in removing the barriers to the beneficial use of these technologies to encourage the sharing of faculty, resources, and ideas across local and national barriers.

Some of the barriers are technical. Cost and compatibility of equipment, already obstacles within countries, are

clearly obstacles between countries. I was pleased to read recently that just last month an international conference of educators called for cooperation among countries in producing international standards for the development of educational software. It seems reasonable to assume that costs will go down eventually, but in the meantime collaborative arrangements among institutions might help make them affordable.

There are also social and political barriers that will have a far-reaching effect on how the new technologies are used. It has been suggested that technology is creating two classes of people, the information rich and the information poor, to add to the numberless other divisions that already exist. It is important to remember that if this does indeed happen, the fault lies not with the technology but with ourselves. Whether computers and satellites and similar devices improve or worsen the human condition depends on us, on whether we use them to include or to exclude.

Similarly, the possibility that the new technologies will draw the international community of learning closer together depends in part on political and social forces. Governments are often less eager than universities to foster the sharing of information and ideas; in the United States we have some experience with this in the tensions that have attended proposals for the scholarly exchange of experts between

American and Soviet universities, for example. Universities can help remove such barriers by insisting on as free an interchange among scholars and institutions as they require within their own academic communities. If universities don't insist on such academic freedoms, who will?

We need to think about these human implications, for in my opinion they, much more than other kinds of barriers, will determine the use--or misuse--of the new technologies. And in terms of the educational process itself, we will make the best use of these technologies by remembering that they are aids to teaching and learning, not a substitute for them. We can give our students access to more information and to a richer educational experience. But we cannot thereby guarantee that they will also experience the intellectual development and integration so necessary to a complete education. Students need more than just information. They need to learn how to make sense out of the information they receive and the experiences they have, to see and understand and create patterns, to come as close as possible to seeing life as a whole. In Eric Ashby's words:

Five centuries of the printed book have not diminished the need for the lecture, seminar, and tutorial. In most fields of knowledge--even in science and technology--the intuitive value judgement, the leap of imagination, the processing of data by analogy rather

than by deduction, are characteristic of the best kind of education. We know no way to elicit these except through dialogue between the teacher and the pupil. The most precious qualities transmitted from teacher to pupil are not facts and theories, but attitudes of mind and styles of thinking.

Of course the new technologies transmit more than facts and theories; and that means it is important to learn more about what happens when humans and machines interact. Is attending a seminar via satellite link the same, ultimately, as sitting in the same room with a professor and other students? Does it make a difference whether a human or an electronic teacher instructs a student in the basics of composition? We know a great deal about how to construct electronic aids to learning; we know less about how this interaction affects students, how large a role it should play in the total educational process, and how we can make it as valuable and beneficial an experience as possible. We need to think hard about all the aspects of the new technologies--technical, economic, political, social, educational--to see that they are used in the best interests of our students, our universities, our society, and the cause of truth and learning.

Universities have always been our link with the past. They are more than ever becoming our link with the future. The

new technologies raise issues and possibilities and prospects for change that are as intriguing and promising as any higher education has ever confronted. And of all the possibilities inherent in the new technologies, by far the most exciting is that articulated in Oppenheimer's dream: that "The unrestricted access to knowledge . . . may make a vast, complex, ever growing, ever changing, ever more specialized world, nevertheless a world of human community."

Thank you.